Golden Sun Moth *Synemon plana* (Lepidoptera: Castniidae): results of a broad survey of populations around Melbourne

Daniel Gilmore[1*], Sally Koehler[1], Cheryl O'Dwyer[2] and Wendy Moore[3]

[1]Biosis Research Pty Ltd, 38 Bertie Street (PO Box 489), Port Melbourne, Victoria 3207
[*] corresponding author email: dgilmore@biosisresearch.com.au
[2]The University of Melbourne, School of Resource Management, Dookie Campus, Victoria 3647
[3]c/o Biosis Research Pty Ltd, 38 Bertie Street (PO Box 489), Port Melbourne, Victoria 3207

Abstract
The Golden Sun Moth *Synemon plana* is a medium-sized diurnal moth considered to be critically endangered in Australia. The discovery of new populations around Melbourne since 2002 suggest that *S. plana* is more widespread and may have less specific habitat requirements than previously thought. A survey was undertaken during the species' 2006/7 flight season, with the aim of improving our understanding of its distribution in the Melbourne area. This report summarises the findings of that survey. (*The Victorian Naturalist* **125** (2), 2008, 39-46)

Introduction

Golden Sun Moth *Synemon plana* is a medium-sized diurnal moth from the family Castniidae, listed as critically endangered in Australia under the *Environment Protection and Biodiversity Conservation Act* 1999 (Fig. 1). The species was thought to inhabit just six areas in Victoria until 2003 when new populations were discovered at the Craigieburn and Cooper Street Grasslands north of Melbourne. In response to these discoveries, a number of targeted surveys for *S. plana* have been undertaken (principally by flora and fauna consultants) on land proposed for development around Melbourne. A report on the discovery of new populations around Melbourne was recently published by Endersby and Koehler (2006).

Discovery of the new populations around Melbourne suggests *S. plana* is more widespread and may have less specific habitat requirements than previously thought (Endersby and Koehler 2006). An investigation has since been under way to improve our understanding of the distribution of the species in the Melbourne area. This report summarises the findings of a targeted survey conducted during the 2006/7 flight season. A second survey is planned for the 2007/8 flight season and it is intended to report on those results once they become available.

Methodology

Survey site selection

Given recent findings, the choice of survey sites for the present survey was based on limited assumptions about habitat suitability.

Criteria for selection of sites were as follows:

- The site supports either native grassland or grassy woodland as the dominant vegetation type;.
- Due to access constraints, sites were predominantly on public land; sites on private land were surveyed where possible;
- Sites were within the species' overall historic range in the outer Melbourne area but were locations where *S. plana* previously had not been recorded;
- Sites were 0.5 ha or greater in size.

Potential sites were identified from a variety of sources, including Parks Victoria, Department of Sustainability and Environment (DSE), City of Hume, Shire of Melton, Biosis Research unpublished data and other sources. Typically, sites were managed primarily for conservation purposes by Parks Victoria or local councils. One benefit of surveying conservation reserves is that it provides information on how well *S. plana* is represented in Melbourne's system of grassland reserves. Survey was undertaken at 30 sites. The surveyed sites are listed in Table 1 and shown in Fig. 2.

Fig. 1. Female Golden Sun Moth *Synemon plana*.

Field survey

Survey was undertaken during the 2006-7 flight season of *S. plana*. The known population of *S. plana* at the Craigieburn Grassland Reserve was used as an indicator to determine when the flight season commenced. As female *S. plana* are cryptic and do not fly regularly, survey focused on the detection of flying male moths (Gibson and New 2007). When male moths began flying in good numbers at Craigieburn, it was assumed that males in other populations around Melbourne would also be flying, thereby allowing detection. The Craigieburn population was monitored from mid October 2006 and thereafter at regular (weekly) intervals until male moths were no longer observed flying. Survey ceased after moths had stopped flying at Craigieburn, which occurred in early January 2007 (W Moore, pers. obs.).

Survey took place on days when conditions were suitable for male flight (> 20 C, bright, clear days, full sun, absence of rain and wind other than a light breeze) between the hours of 10:00 hrs and 14:00 hrs. Weather conditions were monitored on a daily basis using the Australian Bureau of Meteorology weather report for Melbourne as a guide (www.bom.gov.au).

The objective of each survey was to document the presence/absence of the species at a given site. To account for possible between-site variation in emergence time, an attempt was made to survey each site three times during the flight season. While this was achieved for most sites, some were surveyed only twice. Once the species had been located at a site it was not surveyed again.

Only observers familiar with field identification of *S. plana* conducted the survey. It was decided that a transect method of searching would be the most productive for determining presence/absence of *S. plana* (Gibson and New 2007). Transect survey allowed a much larger area to be searched in the limited time available and *S. plana* could often be 'flushed' from the ground by the observer, even when they were not flying voluntarily (D Gilmore, pers. obs.). Survey was carried out by one or two people and transects were generally 5 to 10 m apart to cover the whole site.

On any given day when conditions were suitable for survey, generally one to four

Table 1. Details of the 2006/7 Golden Sun Moth survey sites, Melbourne.

Site	Land tenure	Size (ha)	Survey dates	Search effort (mins)
1 Greenvale	Private	2	8/12/06	30
2 Pioneer Park	Public	3	23/11/06, 18/11/06, 9/11/06	120
3 Banchory Grove	Public	25	23/12/06, 9/11/06, 18/11/06	180
4 Evans Street Grassland	Public	4	23/12/06, 18/11/06, 9/11/06	180
5 Derrimut Grassland Reserve	Public	177·8	10/11/06	300
6 Mt Derrimut Grassland Reserve	Public	30	10/11/06, 21/12/06, 30/12/06	285
7 Altona	Private	49	18/11/06	210
8 Laverton North Grassland	Public	52·3	18/11/06, 19/11/06, 21/12/06	450
9 William Angliss Grassland	Public	68·4	19/11/06	240
10 Iramoo Grassland Reserve	Public	31·1	21/11/06, 21/12/06	240
11 Bush's Paddock	Public	8·9	24/11/06, 18/12/06	300
12 Altona	Private	33·7	24/11/06	120
13 Harcourt Road Grassland Reserve	Public	5·4	24/11/06, 21/12/06	180
14 Laverton North	Private	5·5	24/11/06	100
15 Oaklands Junction	Private	50	28/11/06, 8/12/06	360
16 Woodlands Historic Park	Public	775·4	28/11/06	60
17 Greenvale	Private	Unknown	28/11/06	60
18 Oaklands Junction	Private	50	8/12/06	360
19 Oaklands Junction	Private	Unknown	8/12/06	70
20 Greenvale	Private	Unknown	28/11/06	40
21 Jukes Road	Public	60	23/11/06, 18/11/06, 9/11/06	170
22 Leonard Street	Public	10	23/11/06, 9/11/06, 18/11/06	120
23 Central Creek Grassland	Public	14	10/11/06, 19/11/06, 9/12/06	180
24 Maygar	Public	4	10/11/06, 19/11/06, 9/12/06	300
25 Upfield Railway Line	Public	2·5	11/11/06	40
26 Isabella Williams Memorial Reserve	Public	30	12/11/06, 22/11/06, 7/01/07	300
27 Denton Avenue	Public	3	12/11/06, 22/11/06, 7/01/06	130
28 McCorkells Road	Public	6	18/11/06, 22/12/06, 7/01/07	315
29 Campbelfield Racetrack	Public	2·5	19/11/06	110
30 Laura Douglas Reserve	Public	15	19/11/06, 8/01/07, 9/01/07	140

sites were visited. Each site was surveyed for between one and three hours during each visit, depending on the size of the site and the number of surveyors.

At sites where *S. plana* were recorded, a waypoint location was taken using a hand-held GPS unit. A voucher specimen was collected from each site where the species was found and lodged with Museum Victoria. Specimens were collected under DSE Research Permit Number 10003638.

Results

Present survey

Monitoring of the Craigieburn 'control site' *S. plana* population showed that the 2006-7 flight season commenced around 30 October.

Survey commenced on 10 November 2006 and continued until 9 January 2007, the last date when *S. plana* were observed flying at Craigieburn. Of the 30 sites surveyed during 2006-7, *S. plana* were recorded at 12 (40% of) sites (Fig. 2). Of these sites, five were on public land and seven on private land (Fig. 2, Table 2). Of the sites where the species was recorded on public land, three were in conservation reserves managed by Parks Victoria (Woodlands Historic Park, William Angliss Native Grassland Reserve and Derrimut Grasslands) which increases the number of Parks Victoria grassland reserves around Melbourne known to support the species from two (Craigieburn and Cooper Street) to five.

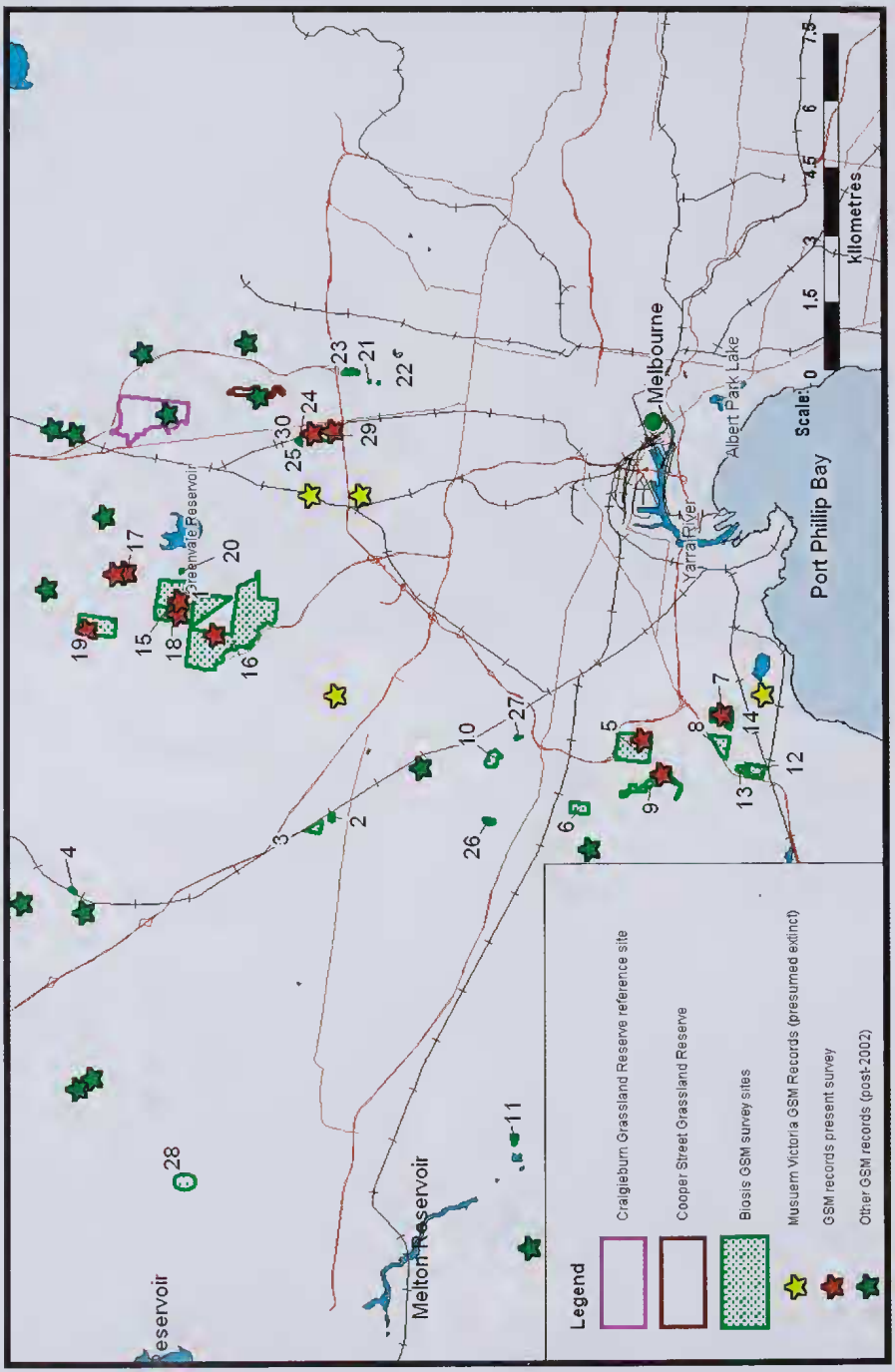

Fig. 2. Survey sites and distribution of Golden Sun Moth in the Melbourne Area.

Table 2. Locations where Golden Sun Moths were recorded during the 2006/7 flight season. NB. All *Synemon plana* were detected on the first survey at each of the listed sites.

Site	Land tenure	Max. no. of *Synemon plana* seen
5 - Derrimut Grassland Reserve	Public	10 males
7 - Altona	Private	500 males, 3 females
9 - William Angliss Grassland	Public	1 male, 1 female
14 - Laverton North	Private	10 males, 2 females
15 - Oaklands Junction	Private	100s of males, 8 females
16 - Woodlands Historic Park	Public	2 males
17 - Greenvale	Private	20+ males
18 - Oaklands Junction	Private	20 males, 2 females
19 - Oaklands Junction	Private	5 males
20 - Greenvale	Private	5 males
29 - Campbellfield Racetrack	Public	2 males
30 - Upfield Railway Line	Public	3 males

An additional site in Meredith (west of Melbourne) was confirmed after discussion with Brian Bainbridge from Merri Creek Management Committee. Biosis Research conducted a survey of the site on 13 December but no moths were recorded.

Interestingly, at sites where *S. plana* were found, they were always recorded on the first survey date (Table 2). If *S. plana* were not recorded on the first date of survey, they were not recorded from that site during subsequent visits. An exception to this was the site at Meredith, where a single female *S. plana* was photographed by the landowner on 24 November 2006. A follow-up survey of this site on 13 December did not find any moths, although the habitat appeared to be suitable. The sky was darkened by thick smoke haze on the day and this may have affected moth activity.

Although no rigorous assessment was made of the size of the populations that were recorded, the number of moths observed varied markedly between sites. For example, only two moths (a male and female) were observed at William Angliss Grassland (Site 9), while an estimated 500 moths were recorded on private land at Site 7 in Altona. Hundreds of moths were also recorded on private land at Site 15 in Oaklands Junction (Table 2). Variation in the number of moths recorded may be an artefact of the lack of systematic survey at sites where the species was recorded, since observers moved to another survey location once the presence of the species at a site had been confirmed. Nevertheless, the largest populations observed were all on private land.

The relatively large number of sites where *S. plana* were recorded around Oaklands Junction/Greenvale may represent a very extensive local population (Fig. 2). However, due to land tenure and time constraints, much of this area could not be fully surveyed.

Previous records

Prior to 2003, there were only four records of *S. plana* from Melbourne. Museum Victoria and the Atlas of Victorian Wildlife have records from the early 1900s from near Keilor, Broadmeadows and Laverton (Fig. 2). The current status of these populations is not known. However, due to loss of habitat they may be extinct.

At least 15 *S. plana* populations (sites), additional to those found in the present study, have been discovered in Melbourne's north and west since 2003 (Endersby and Koehler 2006; Biosis Research unpub. data). These include populations discovered in the Craigieburn and Cooper Street Grasslands in 2003 (Van Praagh 2004; Endersby and Koehler 2006).

Most of these additional populations were discovered as part of flora and fauna assessments of grasslands that will be lost to residential development. Due to their recent nature, details of these populations were sourced mostly from unpublished consultant reports and discussions with the Merri Creek Management Committee and DSE. Locations of all known populations of *S. plana* near Melbourne are shown in Fig. 2.

Discussion

The results of this survey suggest that the methods used were appropriate for detecting *S. plana* at a range of sites around Melbourne.

Surveys since 2003 have located at least 27 new *S. plana* populations (sites) around Melbourne. The current survey alone documented 12 (44%) of these new localities. This apparent surge in records reflects a greater understanding of the peculiar survey requirements of the species and greater survey effort in recent years. It is also likely that our increased knowledge of the species' habitat has led to surveys in areas previously deemed unsuitable. The present survey, combined with other surveys conducted since 2003, confirms that *S. plana* is widespread but patchily distributed on Melbourne's northern and western outskirts.

Many of the sites where *S. plana* recently has been recorded support habitat very different from what previously was considered suitable for the species. Indeed, many of the sites support a much lower cover of *Austrodanthonia* spp. than the 40% previously thought necessary to support the species (O'Dwyer and Attiwill 1999). It is now well established that *S. plana* has much broader habitat requirements than previously thought (Clarke 1999; Endersby and Koehler 2006; Gibson 2006). The findings of the present survey largely concur with these previous studies.

Although *Austrodanthonia* grasses were present at all sites where *S. plana* were recorded, this genus is a widespread component of grasslands around Melbourne, even in patches supporting predominantly introduced vegetation. Many of the sites where the species was recorded were heavily infested with Chilean Needle-grass *Nassella neesiana* and other exotic grasses. It has been suggested that *S. plana* may not be restricted to using *Austrodanthonia* as larval food plants and that it may feed on other grasses including species from the genera *Nassella* and *Bothriochloa*. While the present survey could not confirm this, female *S. plana* were observed ovipositing on *N. neesiana* on several occasions and cast pupa cases of this species were found among a dense sward of *N. neesiana* at Oaklands Junction. Braby and Dunford (2006) have also observed *S. plana* ovipositing on *N. neesiana*. In addition, the species has been observed ovipositing on spear-grasses *Austrostipa* spp. and Weeping Grass *Microlaena stipoides* (Gibson 2006). Culture of larvae in a controlled environment is the only way to determine conclusively if *S. plana* can successfully complete their life cycle on grasses other than *Austrodanthonia*.

It was beyond the scope of the current survey to undertake detailed habitat investigations at sites supporting *S. plana* and compare these to unoccupied sites. A number of qualitative observations were made of sites where *S. plana* were recorded in 2006-7. Compared to unoccupied sites, sites supporting *S. plana* tended to be relatively low, open grasslands with areas of bare ground (inter-tussock space). At one site supporting both closed grassland and open grassland in close proximity, dense swards of grasses such as Kangaroo Grass *Themeda triandra* appeared to be actively avoided, with male moths confining their patrolling activities to an area subject to regular mowing. This is consistent with the observations of other authors, who also found *S. plana* to be more abundant in areas that were relatively open with a reduced biomass (Gibson 2006). It is possible that patrolling male moths prefer these areas because it makes it easier for them to locate displaying females (Gibson 2006).

Most of the occupied sites were subject to regular biomass reduction activities including livestock grazing, herbicide application, slashing and fire.

Over half of the sites where *S. plana* were recorded during the present survey were on private land and 11 (73%) of the 15 additional localities shown on Fig. 2 are on private land.

The future for *S. plana* on private land sites is uncertain, since they are generally not managed for conservation and some are under imminent threat from urban and industrial development. Many of these sites appear to support large populations of *S. plana* and, with the exception of Craigieburn Grassland Reserve, the species may be more abundant on these sites than in conservation reserves. However, it is important to note that the true extent and size of many of the populations at known sites is poorly understood (see further work below).

Even the populations on public land are not necessarily secure, since some of these sites are not managed for biodiversity and some, such as the land reserved for the proposed Deer Park Bypass, will be affected by habitat removal in the near future.

Although focusing on public land, with limited searches on private land, the survey confirms that the species is widespread north and west of Melbourne.

The extent and size of the populations still need to be determined at the identified sites, particularly those in conservation reserves such as Derrimut Grassland. This information will assist in determining the relative importance of populations and establishing priorities for conservation and management. Information gathered during the 2006-7 study highlights the need to further refine knowledge of what constitutes optimal habitat for *S. plana*.

In the past, surveys for *S. plana* in Melbourne and elsewhere in the species' range have not focused on private land (Clarke 1999). However, it is suspected that *S. plana* may be widespread on private land on Melbourne's northern and western outskirts. Knowledge that the species has broader habitat requirements than previously thought opens the possibility that suitable habitat is more widespread and indicates that the potential to locate additional populations has increased (Clarke 1999). Therefore, future surveys should attempt to gain access to a greater number of sites on private land, particularly locations where habitat meets the minimum requirements now known for the species.

An inherent limitation of this study was that site selection was based on the presence of either native grassland or grassy woodland. However, it is known that *S. plana* can occur in highly modified grasslands, including sites supporting predominantly introduced grasses (Clarke 1999; Braby and Dunford 2006; Endersby and Koehler 2006; this study). Apart from a few sites on private land where exotic grasslands occur, the current study focused on areas supporting native vegetation. By selecting sites supporting mostly native vegetation, this study was inherently biased. It would therefore be of value for future surveys to assess grasslands of varying quality, including those dominated by introduced species.

The life cycle of *S. plana* is thought to be 2-3 years, in common with other members of the genus (Edwards 1994). This raises the possibility that at any given site there may be two cohorts (populations) of *S. plana*, which emerge on alternate years, and that one of these cohorts is larger than the other (e.g. Endersby and Koehler 2006). While this may be the case, there is no information to suggest that there are years when moths do not emerge at an occupied site. Indeed, at Craigieburn, where the population has been regularly monitored since 2003, moths have been observed each year, albeit with varying population sizes (W Moore, pers. obs.). This is also the case for occupied sites in the ACT (T Edwards, pers. comm.).

It is interesting to note that at each site where *S. plana* were recorded, the recording was on the first day of survey. In devising a methodology for survey of *S. plana*, we believed that it would be necessary to survey sites a total of six times over two flight seasons (to account for a possibility that adults do not emerge every year) to be reasonably confident that the species was, or was not, present. Data from the current survey suggest that such intensive survey effort may not be warranted, provided that the site is systematically searched using the transect method, and surveys are undertaken under ideal conditions, preferably in the middle of the flight season (when moth abundance peaks) and conducted on days when flying is confirmed at a known reference site nearby. Confirmation of flying at known sites nearby may be the most important consideration when planning presence/absence surveys for the species (Clarke 1999). Based on the results of the current survey, it appears that the onset and cessation of moth emergence does not vary substantially between sites within a region, presumably because of similarities in climatic variables such as temperature and rainfall, which are suspected to affect emergence time. Nevertheless, caution needs to be exercised when interpreting the results of surveys undertaken early or late in the flight season, as subtle inter-site differences in the onset and cessation of emergence are still likely.

Conclusion

Based on the results of our survey, we believe that the survey effort required to be reasonably confident *S. plana* is present at a given site can be reduced to two visits in one flight season (provided the steps highlighted above are adhered to). This is consistent with the survey effort recommended by Clarke (1999). By reducing the need for repeat surveys, the number of sites surveyed can be substantially increased during a season, which is important for species whose 'window' of detectibility is limited in any given year.

The Golden Sun Moth is more widespread and apparently more abundant in the Melbourne region than previously thought. The implications of these findings for the conservation status of the Golden Sun Moth ultimately will need to be considered.

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One Hundred Years Ago

EXCURSION TO THE YOU YANGS

Presently the rock mass came in view, and on reaching it we were astonished at its extent. It must be nearly 100 yards in diameter, and at its southern edge rises about 80 feet above the hillside, the northern edge being flush with the mountain side. Some one with a penchant for figures has calculated that it contains about 4,000,000, cubic feet of stone, and would weigh about 300,000 tons.

From *The Victorian Naturalist* **XXV** p. 126, December 1908